AN INTRODUCTION OF SIMULATION UTILIZING THE MONTE CARLO METHOD OF ANALYSIS AS A TOOL FOR U. S. COAST GUARD PERSONNEL ADMINISTRATION

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

HISTORICAL BACKGROUND[1]

Like many other organizations, the United States Coast Guard evolved from simple origins. Conceived in 1790 as the Revenue Cutter Service to insure the success of Alexander Hamilton's bold economic plan, it has served as a federal law enforcement agency and insurer of safe navigational practices. Many of the agencies born during the Washington administration maintained their unifunctional mission throughout history. However, the Revenue Cutter Service earned a reputation for expertness in dealing with a variety of assignments, and when the federal government centralized some of the smaller agencies to eliminate duplication of effort and better utilization of resources, the Revenue Cutter Service was the logical guiding influence. With an increase in size and responsibility, the Revenue Cutter Service became the Coast Guard.

In 1915 with the amalgamation of the Revenue Cutter Service and the Lifesaving Service to form the Coast Guard, President Taft's principle of organization and combination was applied to several of the federal agencies dealing with maritime law and safety. This unification of protective maritime services gave the Coast Guard the

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[1]Stephen H. Evans, CAPT, USCG, The United States Coast Guard, 1790-1915, A Definitive History (Annapolis: The United States Naval Institute, 1949), pp. 3-220. passim

responsibility for sundry preventive and law enforcement functions which had formerly been vested in the parent agencies.

With the declaration of war in 1917, the Coast Guard was transferred to the Navy providing men and ships for ocean rescue work, while at the same time fulfilling its previous commitments.

In 1936, Congress designated the Coast Guard by law to be the federal arm for the enforcement of U. S. laws on the high seas and navigable waters of the United States. In 1939, with Congressional authority to reorganize the Executive Branch of the government, President Roosevelt amalgamated the Lighthouse Service with the Coast Guard, thus beginning the unification of federal services primarily concerned with the prevention of marine disasters.

With the outbreak of war, the Coast Guard was once more transferred to the Navy, furnishing trained forces for combat operations at the same time maintaining its normal peacetime duties somewhat extended and intensified. Because of the importance of merchant marine safety and law enforcement during this period, the President, in 1942 consolidated the Bureau of Marine Inspection and Navigation (comprising the former Steamboat Inspection Service and Bureau of Navigation) with the Coast Guard. The year 1946 saw the Coast Guard assigned the responsibility for furnishing search and rescue facilities and services to meet the United States obligations to the International

Civil Aviation Organization (ICAO) for the protection of international civil aviation over water areas. This obligation was extended in 1948 to include prevention and protection, thus requiring the maintenance of ocean station vessels. The most recent obligation assumed by the Coast Guard is the responsibility to participate in a comprehensive ten year program of oceanographic research and survey as set forth by public law 87-396.

Conceived and developed as a multifunctional organization, its character remains unchanged today. However, one important change has taken place. From 1790 to 1962 as the small organizations have been amalgamated into the Coast Guard they have brought with them varied responsibility and groups of highly motivated individuals. The varied responsibility remains, but the highly motivated specialists are passing with time.

Unless one has been a student of the Coast Guard officer personnel structure or is an experienced personnel administrator, it would be difficult to visualize the complexity of the organization with regard to the variety of background and special talents. Referring to Figure I, which illustrates a complete distribution of officers as to rank and source of commission as of 1 July 1960, one can gain a better insight into the heterogeneous complex.

If the distribution of officers shown in Figure I, were further categorized by longevity groups, a greater variance would be introduced than is already present.

Although small in size compared to the other services, the problems of administration are just as great, and the methods of handling them are not always as advanced. To illustrate this, in a study recently completed by LT. Arnold M. Danielsen concerning the officer retention problem in the Coast Guard, the following observation was made.

> ...it should be remembered that in the two and one-half year period covered by this study the Coast Guard lost 108 officers through resignations and voluntary retirements. During such a period of time an almost complete turnover of reserve junior officers (Ensigns and Lieutenants, Junior Grade) is also experienced. A scattering of other officers also leave the service for reasons of physical disability. Giving due consideration to these facts, it is the opinion of this writer that a problem does exist and the hope is that more light may be shed on the problem through this study.[2]

In view of this statement and recent announcements of new officer management policies for the Coast Guard, I felt that the introduction of a new tool with which our administrators might better predict and plan for the personnel needs of the future was in order.

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[2]Arnold M. Danielsen, "A Study of The Problem of Retention of Junior Officers of The United States Coast Guard" (unpublished Research Paper, U. S. Naval Postgraduate School, Monterey, California, 1961), p. A-8.

A general description of personnel problems which might be studied by simulation are presented in Chapter II. The problems have been chosen to serve as a testing ground for the method of analysis being introduced, and have not been presented with intention of developing solutions. Chapter III presents a general description of a personnel simulation, considering many factors which influence the personnel structure and should be considered in any planned personnel projection. To illustrate how the theoretical model of Chapter III might be utilized by the Coast Guard for problem solving, several simulations are presented in Chapter IV which are considered illustrative and not necessarily valid solutions. This point is brought out to dispel any over expectations that may be generated by Chapters II and III.

TABLE I

DISTRIBUTION OF COAST GUARD OFFICERS BY SOURCE

AS OF JULY 1, 1960 *

	U. S. COAST GUARD ACADEMY	INTEGRATED FORMER RESERVE, WARRANT OFFICER, OR ENLISTED GENERAL DUTY	REGULAR INTEGRATED PL-219	SPECIAL DUTY REGULAR AND TEMPORARY SERVICE	TEMPORARY SERVICE GENERAL DUTY	EXTRA NUMBERS	RESERVES	TOTALS
ADMIRAL	16	1	0	0	0	0	0	17
CAPTAIN	165	10	0	0	0	63	1	239
COMMANDER	157	97	9	54	1	18	33	369
LCDR	192	173	47	62	26	1	43	544
LT	411	62	46	16	119	0	38	692
LTJG & ENS	348	7	5	0	307	0	412	1079
TOTALS	1289	350	107	132	453	82	527	2940
Percentage	43.9	11.9	3.6	4.5	15.4	2.8	17.9	

* Ibid., p. A-9.

CHAPTER II

THE PROBLEM

Statement of the problem. Most basic economic courses set the ground work for study by presenting three questions to the students. What commodities shall be produced and in what quantities? How shall the goods be produced? How should the total product be distributed? In attempting to define one of the personnel problems facing the administrators of the Coast Guard today, I have chosen a similar approach. How many officers should the Coast Guard plan to commission each year? What percentage of officers should be Academy trained, and how should this group be supplemented? To which fields should the officers be channeled to supply sufficient manpower from the standpoint of quality and quantity? These are very difficult questions to answer because of the degree of uncertainty involved, yet decisions must be made considering these factors if the organization is to be planned for the future. This point is brought out by Janowitz in his book *The Professional Soldier* when he states:

> The second problem in transforming the military profession into a constabulatory force is its skill structure. Skill changes in the military profession have narrowed the difference between military and civilian occupations. The professional soldier must develop more and more skills and orientations common to civilian administrators. Yet, the effectiveness of the military establishment depends on maintaining a proper balance between military technologists, heroic leaders, and military leaders. The constabulary force will depend on the military manager to

> maintain this appropriate balance. He is better equipped today to participate in the management of international security affairs than in the past, not only because of the improved quality of military education, but also because his day-to-day tasks develop broader administrative skills.[3]

At the outset it must be understood, that this paper makes no attempt to produce solutions for the aforementioned problems, but merely offers a means for gaining a slightly better insight of the uncertainties which inhibit better personnel planning.

Need for the study. As a result of the personnel procurement policies in existence after World War II, most of the armed services are faced with an unbalanced distribution of personnel in certain year groups of the officer ranks. This unbalance, often referred to as "the hump", has not adversely affected the Coast Guard officer management system to date, because of the steady growth of the service which has compensated for it.

A recent study conducted by the Bolte Commission for the Department of Defense reiterates the need for certain guidelines or methods by which the services can build solid organizations, at the same time maintain a state of readiness and allow for the satisfaction of certain individual values.

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[3] Morris Janowitz, The Professional Soldier (The Free Press of Glencoe, Illinois, 1960) p. 424.

> The basic philosophy of the committee is that the primary purpose of an officer management system is to provide officers sufficient in quality and quantity and in appropriate ages and grades to officer the military forces of the nation. That system could provide a smooth flow of promotion, and should fulfill the grade distribution requirements of each service. The system should be sufficiently circumscribed by law to prevent frequent changes which destroy confidence in a system yet flexible enough to permit proper administration.[4]

Although the problem of "the hump" has not affected the Coast Guard as yet its presence can be sensed close at hand by the recent announcement of the Commandant that a board headed by RADM Joseph A. Kerrins had set forth proposals for a revised officer promotion program which parallels in many respects the aforementioned Bolte Study. It is safe to assume that very shortly we will be faced with the problem of what to do with our excess officer personnel in the unbalanced year groups. With this point in mind, how can we be sure that we are not creating more problems in years to come with our present personnel policies.

It is my feeling that the most important phase of the officer management problem is determining in advance how many officers we should commission, from what source they should come, what special training they should receive and how they should be utilized. As

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[4] Ad Hoc Committee to Study and Revise the Officer Personnel Act of 1947, A Concept of Career Management For Officer Personnel of The Armed Services, 1961.

indicated in Chapter I, the officer ranks are composed of a heterogeneous group of individuals with considerable variance as to background and length of service. This situation presents to the personnel planners decision problems steeped with uncertainty as to how and when these officers should be replaced. The decision problems are brought about by the lack of knowledge on the part of the planners of the consequences to any of the alternatives open to them. The lack of complete information concerning a current situation leads to uncertainty in the decision makers mind as to what the actual state of conditions are at present. Thus we are faced today with a situation of not really understanding the factors that affect our current personnel structure and yet we are compelled to make decisions which affect the personnel structure twenty years hence. In effect we don't understand how we got where we are, yet we must dictate how to proceed from here.

It is with these points in mind that I indicate a need for better tools to remove some of the uncertainty from the personnel decision problems, in order that sound policies can be set.

Purpose of the study. The purpose of this study is to introduce to the personnel administrators of the United States Coast Guard, simulation by the Monte Carlo method of analysis as a tool for management.

A personnel simulation model of the Coast Guard officer ranks has been constructed to illustrate the potential of simulation as a

tool for personnel planning, the simplicity of construction and manipulation, the versatility of its functions, and the need for empirical data on personnel problems.

A hypothetical model considering many possible factors is described and several less sophisticated models considering the probability of resignation and retirement have been constructed for illustrative purposes.

It is anticipated that this tool will provide a quantitative approach to decision problems, considering the whole officer personnel composition as a system, or looking at the smaller segment and components as the needs arise. It is felt that with this tool, a better prediction of future service needs can be made by utilizing past performance data as criteria for future decisions.

Definitions of terms used.

Model. A representation of reality that attempts to explain the behavior of some aspect of it.

Analog Model. A symbolic or mathematical presentation of a physical model, which tends to be more abstract than physical.

Simulation Model. An analog model which contains time as an active dimension with the output feedback as a new input proceeding in stepwise fashion to produce a sequence of outputs. Since time can be speeded up as an input, years of results may be obtained in a few

hours of simulating, hence this type of model has particular significance to business and to the study at hand.[5]

Monte Carlo method of analysis. The application of simulation to situations characterized by statistical distributions that are not of well known forms. Many times several probability distributions interact with each other in special ways and it is not possible to solve for their combined effect in a mathematical equation.[6]

Probability. The proportion of times that an event will occur in an infinite series of repeated trials of the same kind, which can never be determined exactly.

System. Any entity, conceptual or physical which consists of interdependent parts.[7]

Behaviorial system. Those systems which display activity.[8]

Operation. The behavior displayed by a system which consists of a set of interdependent acts.[9]

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[5]David W. Miller and Martin K. Starr, Executive Decisions and Operations Research (Englewood Cliff, New Jersey: Prentice-Hall, Inc., 1960) p. 119.

[6]Ibid., p. 133.

[7]Donald P. Eckman, Systems: Research and Design (New York: John P. Wiley & Sons Inc., 1961) p. 27.

[8]Ibid.

[9]Ibid., p. 28.

Optimum alternative. The existence of a set of criteria that permits all alternatives to be compared and the selection of one in preference over all of the others.[10]

Satisfactory alternative. The existence of a set of criteria which describe the minimal satisfactory alternatives and the selection of one which meets or exceeds the set of criteria.[11]

Role. The repetition of the performance of a series of specialized activities which are recognized by observers to be the role of the performer. In essence it is an abstract entity reflected through its interpretations.[12]

Randomness. Although the word random is used extensively in the study of statistics it is very difficult to define. It infers that the process or procedure referred to takes place in a haphazard manner within certain limits and does not conform to an ordered sequence. For example, Janowitz points out that in 1950 the regional background of naval officers was: twenty seven percent from the northeast, thirty one percent from the south, thirty percent from north central and twelve percent from the west, however, if we had checked any one

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[10]James G. March and Herbert A. Simon Organizations (New York: John Wiley & Sons Inc., 1958) p. 140.

[11]Ibid.

[12]Harvey Leibenstein, Economic Theory and Organizational Analysis (New York: Harper & Brothers, 1960) pp. 129-130.

command in 1950 we would probably not have found this exact distribution. If numerous commands had been checked, the average distribution would have approached the actual service distribution and the findings of any one command could be considered random. It should be noted that there are no degrees of randomness, it is either random or it is not.[13]

Random numbers. In order to simulate a random process without rolling a die for each value of interest, sets of random numbers have been compiled and distributed as random number tables. Each set of numbers consists of a long series of digits zero thru nine, each occurring substantially an equal number of times, and in an order that statisticians accept as random.[14] See Table VII.

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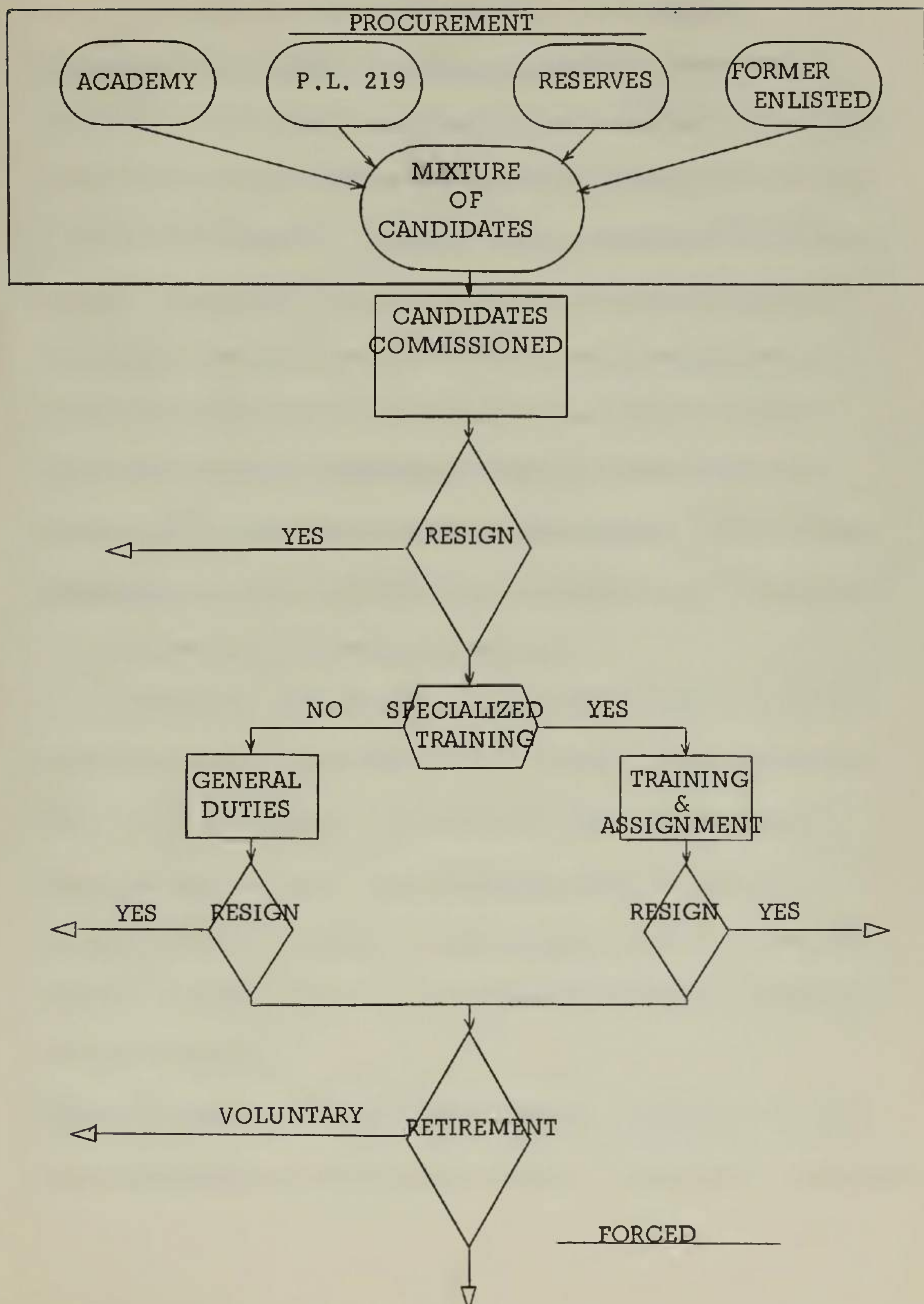
[13] Janowitz, op. cit., p. 88.

[14] L. H. C. Tippett, The Methods of Statistics, (New York: John Wiley & Sons, Inc.) pp. 51-52.

FIGURE I
FLOW DIAGRAM OF OFFICER
ATTRITION MODEL



CHAPTER III

METHODS, TECHNIQUES AND PROCEDURES

Construction of a hypothetical personnel model. A model representative of the entire Coast Guard officer personnel system should consider all facets of personnel management from the point of origin to the point of departure. A model such as this should consider such things as: the world situation, economic restrictions being placed on the service, sources of potential officers, basic requirements of a Coast Guard officer (technical versus non-technical), prevailing rates of natural attrition through retirement and resignation, the desired career pattern (specialist versus generalist), the overriding probability of death and disability, and finally the rank versus length of service structure desired by the service.

Describing a system such as this is much simpler than constructing a model representative of it. However, making decisions involving the interactions of the aforementioned factors is much easier and less uncertain when considered quantitatively in a systemized fashion. In constructing this hypothetical model two components have been utilized, an input generator, and the operations or attrition segment.

The input generator. Prior to conducting the simulation of a system or process certain parameters and goals must be set down, thus giving

direction and setting limits within which the model will operate. It is through the input generator that most of these factors are introduced. In discussing these factors, I have categorized them as controllable or uncontrollable.

Of the input factors mentioned earlier, the only one which can be considered as controllable is the source of potential officers utilized. This factor is controllable from the standpoint of the freedom that exists in determining the mix of academy trained, intergrated reserves, former enlisted, and Public Law 219 officers. In determining personnel policies it is possible to exercise some control over the proportion of individuals from the various sources, the training received by the prospective officers, and the prerequisites for selection.

Referring to Figure I, it is obvious that the Academy has supplied less than fifty percent of the present officers, which is probably not by design. However, when all factors are taken into consideration in a personnel model, it may be possible to determine the correct distribution of input to not only replace the present officers but allow for a smooth flow of promotion with the minimum of forced attrition. This type of plan would allow more officers to seek their level of career achievement with a higher degree of certainty and continuity.

The remaining factors of concern to the input generator are uncontrollable in nature but must be considered as basic inputs to a

personnel simulation model. The first of these is the world situation which often times dictates increased manpower needs and could, in light of present unification and disarmament talks set constraints on the personnel force. This is a factor which must be constantly studied in an effort to overcome the lead time necessary to adjust the personnel forces with some degree of continuity. Industry has recognized this fact as Leibenstein points out in his book Economic Theory and Organizational Analysis.

> Unlike most factors of production, labor cannot always be purchased in the form in which it could be immediately used, nor can it be purchased outright. ... This unique aspect of the labor factor creates certain organizational problems not involved with other factors.[14]

The next set of factors to be considered in the input generator which are uncontrollable from the standpoint of the personnel administrators, are the requirements placed on an officer by the roles and missions of the service. Being a multifunctional agency, which is an interdependent part of a dynamic society, the requirements of the service officer become dynamic and cannot be considered as static as they have in the past.

To illustrate the point, with the Coast Guard's increased emphasis on the research and development of electronic navigation

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[14]Leibenstein, op. cit., p. 276.

equipment, and the problems of merchant marine safety, the technical requirements of the service officer are increasing while the time for selection and training is remaining constant. Without considering this factor as an input how can the trainee of today be educated to fulfill the career requirements that will face him in 1975. Morris Janowitz, in a study prepared for the American Sociological Society came up with the following observations which point out the need for better decisions in military education planning.

> In fact, the typical professional officer spends almost one quarter of his career in school or in training situations. For the individual officer this can be a difficult and painful process; for the organization, it means facing the equally unpleasant fact that persons who were successful early in their careers may not show aptitudes for later career requirements and vice versa.[15]
>
> The classical military solution to the dilemmas of career development has been to maintain the belief that the officer must be a generalist. Each of the services has developed a set of assumptions as to the components of an ideal military career and its educational system is geared to the development of this career line. Like all organization "myths", these assumptions are essentially correct in indicating the paths of advancement, but in many cases they may be inadequate in preparing personnel for emerging tasks.[16]

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[15]Morris Janowitz Sociology and the Military Establishment (New York: Russell Sage Foundation, 1959) p. 58.

[16]Ibid., p. 59.

> Military education has been subjected to the criticism that it has been isolated from the main intellectual currents. In particular, instruction in the basic disciplines (non-military subjects) has suffered because the instructors have not been specialists. Military education has, in fact, been a form of self-education, and often the instructor has represented a service orientation rather than a formal educational experience.[17]

The final factors to be considered with the input generator are the economic restrictions which must be weighed in all phases of planning, as indicated by the Coast Guard Organization Manual:

> However, there must be in the mind of each member of the Coast Guard organization a constant awareness of the fundamental charge upon the service which is paramount to and superimposed upon the specific duties of each segment of the organization. The basic charge demands at all times the performance of every Coast Guard duty in the most efficient and economical manner.[18]

The constant need to maximize the utilization of resources cannot be overlooked in the formulation of future plans. By applying the economic limitations as a goal for operations the personnel model may be manipulated for alternative plans, cost studies made without actually placing the plans in effect, and determination made of the optimum alternative. An illustration of a problem which the service may face shortly that lends itself to simulation is the increasing cost of retirement pay.

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[17] Ibid., p. 60.

[18] U. S. Coast Guard, Organization Manual, CG-229 Washington: U. S. Coast Guard, 1950), p. XII.

A decision to restrict voluntary retirements in an effort to reduce overall expenses could be simulated for several alternative plans. The results of these plans could be costed out for all predictable reactions and comparisons made with projected costs of the present policies. In this way, the optimum alternative could be selected prior to any policy statement.

There are undoubtedly many more factors peculiar to different organizations and to this organization which should be considered in future personnel models, however this at least offers an indication of the type of data which must be collected and studied prior to any complete personnel simulation.

<u>The operations or attrition segment</u>. The second segment of the personnel model consists of a flow diagram of the individual from the time that he is commissioned to the time that he leaves the service. Using the output of the input generator, the data is fed to the operations segment which consists of several controllable and uncontrollable factors. The forces making up the operations model have been the subject of much research and study, and for the purpose of this paper it is merely a matter of recognizing that they exist, and that they do affect the flow of an individual from input to departure. A recent study by Harvey Leibenstein of the University of California, Berkeley pointed out this fact.

> ... since the labor is not always available in the form desired, some investment in the selection and training of workers may be unavoidable. To achieve an adequate return from such an investment, the organization must devise schemes to induce the workers to remain with it. ... From the point of view of the careerist we visualize a sequence of roles connected with each other in such a way that they form a reasonable path to some desired role - a role that is the ultimate aim of the one traveling through the sequence of rolls.[19]

Observing the path of an individual through the operations segment several decision points are noted. Having been commissioned and in the organization three or four years, the decision to resign or not resign faces all of the officers transiting the system. The decisions made by officers concerning these particular alternatives have been the subject of much research and the ability to predict the individual's choice is improving with increased data and improved statistical methods. This decision point is controllable from the stand point of time of occurrence (length of obligated service), but not the proportion of alternative selections. Continuing the flow chart, the next decision considered is whether the individual selects a specialty or remains a generalist. This is a controllable decision from the standpoint of officer management, whether an additional investment should be made in hopes of improving his utility to the organization, or not investing and utilizing the individual as the needs of the service require.

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[19]Leibenstein, op. cit., pp. 276-277.

For purposes of illustration, the path of operations splits at the point of specialty, although there are no facts to indicate that the attrition rate of special trained officers differs from that of non-specialists. With regards attrition, the next point of decision is when to retire. Having reached the twenty year mark, the individual is constantly faced with the decision of retire or not retire. This factor is controllable in several ways, the amount of money budgeted for retirement pay, the minimum time in service before becoming eligible for retirement, increasing or decreasing the probability of promotion for certain individuals to restrain or encourage retirements, and finally legislated personnel policies requiring retirement at the discretion of annual personnel evaluation boards.

The probability of death or disability is an uncontrollable factor which must be considered in any attrition model, with the prevailing rate being determined for the system by statistical analysis.

Utilization of the model. Having decided on the inputs and parameters of the problem, the system may be simulated through the period of interest and the output analyzed. What is the output? The output of a simulation represents an average or expected outcome about which a range of outcomes may be determined. As will be explained in Chapter IV, this range of possible outcomes allows for the random distribution of conditions or values about an average condition or value. Having determined the average outcome, it may be compared

with an ideal situation or a standard against which work is being performed. If the range of outcomes do not conform to the parameters of the problem, it is necessary to return to the model and manipulate the controllable factors. With this manipulation, an average outcome may be generated which does conform to the parameters that have been set. This does not provide an exact prediction of the future, but simply improves the chances of a particular state coming into being. To create this specified state at some future date it will be necessary to set policies earlier that have been tested by simulation and to continually observe this system making sure that it remains in control within the range of predicted outcomes, modifying policy as necessary and as better data becomes available.

For example, if a personnel model as previously described had been simulated repeatedly and the expected outcome fourteen years hence produced a serious unbalance within certain year groups requiring forced attrition, what avenues would be open for study? Looking at the model, the only factor we considered controllable as an input was the source of officer material. Rebuilding the model and simulating, it might be determined that if a larger proportion of individuals with prior service had been commissioned they would be moving into the retirement zone and part of the unbalance would be alleviated in a natural manner.

CHAPTER IV

ILLUSTRATIVE SIMULATIONS

General description. In an attempt to better illustrate the potential of personnel simulation, a model has been constructed of the officer corps of the Coast Guard as it existed in 1959 and several simulations have been conducted. For the purpose of these simulations, the Monte Carlo method analysis has been utilized, because of the complexity involved in determining mathematical representations of all of the forces concerned with personnel attrition.

The Monte Carlo method of analysis, as defined earlier, requires the application of probability distributions which have been previously determined by statistical analysis. These probability distributions are applied by means of assigning random number intervals to them and selecting from random tables, numbers which are representative of a decision being made or an event taking place. As an example, if the probability of an individual resigning after four years of service is .06, then six numbers out of one hundred numbers (0 - 99) would be assigned to represent resignation decisions while the other ninety four numbers would represent decisions to remain in the service. Thus, after many repetitions of this process an accumulation of decisions results which is nearly identical to the decision pattern which had been previously determined by analysis.

Assumptions made for this model. For purposes of simplicity and clarity certain basic assumptions have been made prior to the construction of this model:

1. It is possible to determine at any particular time in an individuals career the overall probability of a group of like individuals resigning based on the amount of service that the group has completed.
2. It is possible to determine at any particular time in an individuals career the overall probability of a group of like individuals requesting retirement based on the amount of service that the group has completed.
3. The volunteer retirement policies of the service will remain unchanged.
4. The number of officers offered direct commissions or intergrated above the rank of ensign will be so small that it will not affect the present organization structure.
5. Revocations can be considered with resignations in determining a resignation probability.
6. The probability of death or disability can be combined with the retirement probability.
7. The submission of resignation and retirement requests do not occur in ordered sequence and can be considered a random occurrence.

8. The data concerning extra number retirements can be disregarded without destroying the validity of the model.

Statistical analysis. Prior to conducting the illustrative simulations for this paper, it was necessary to make several assumptions, which have been listed previously, and then to compute the probabilities necessary for the model. Having decided to consider the probabilities of resignation and retirement as the operating functions of the model, a need existed for historic data from which these probabilities could be determined. A request was submitted to the Commandant (P), United States Coast Guard, advising him of the need for specific data concerning retirements and resignations. All of the information available to this source was forwarded, but unfortunately it was not adequate for determination of the required probabilities.

Utilizing the only available source of data, the information was extracted from the Register of the Commissioned and Warrant Officers and Cadets of the United States Coast Guard, CG-111.

The officer structure was segmented by year groups and further divided into longevity groups. The year group delineations were obvious from the Register, but the longevity groupings had to be determined by utilizing the date eligible for thirty year retirement. As illustrated in Table II there is considerable longevity variance within the individual year groups, making group attrition predictions more difficult.

TABLE II

LONGEVITY DISTRIBUTION WITHIN YEAR GROUPS OF COAST GUARD OFFICERS 1929 - 1959. (EXCLUDING EXTRA NUMBERS)

(Based on data extracted from CG-111 dated 1 Aug. 1959)

LONGEVITY	YEAR GROUPS																													
	[illegible]	56	[illegible]	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	36	35	34	33	32	31	30	29
0	8																													
1	[illegible]	23				7																								
2			4	1		1	5																							
3				50	1				3						3															
4						[illegible]	2																							
5						59	3		5		3			1																
6		4	[illegible]		[illegible]	6	49		4		3						1													
7	4	6	6				3	36		3	1		1																	
8	7	2	3	[illegible]	[illegible]		3	1	37		6					4														
9	[illegible]	3	[illegible]				3	[illegible]	5	39			13		1	6														
10	6	6		[illegible]	10		2		3	21	24		16			1	3													
11	10	5	[illegible]	2					1	5	3	18	3		4															
12	14	10	14	6	1	2	3		1	1	5	19	5																	
13	[illegible]	10	8	7		5	3		13	3	4	3	12	51		3														
[illegible]		8	1	[illegible]	[illegible]		1	2		3	1		8	1	48	16														
[illegible]					3	1	3		1		1		3	1		50	4													
[illegible]			[illegible]			[illegible]					2		1	1	21	4	48	3		1				16						
[illegible]						3	1		3		4			2	5	9	17	66	4		28	1	1	1		1				
[illegible]				1	[illegible]	2	3	1	6		4		3	1	9	17	3	25	15	2	7			4						
[illegible]				1			4		6		4	1	3		8	4	2	1	2	12	3						1			
[illegible]							5	3	5		1	1	3		3	13	5	3	3		1									
[illegible]								2	1		5				5	4	1	1		1	16	17				1				
[illegible]									2		3		3		5	3	4	1	1	1	2	14					1			
[illegible]							1		2		3		2		7	2					2	3	20							
[illegible]									1		6		2	1	3	3	2						4							
[illegible]											2		1		4								1		2					
[illegible]													1		4		1	1				1	2		1	17				
[illegible]											4		3		3		1	1									18			
[illegible]													5		1			1				1				2	3	16		
[illegible]															1		1	3			1						2	4	7	
[illegible]																	3	1	1									3	7	2
[illegible]													1		1		2	1												
32																	1		2											
33																					1									1
34															1		1	2	1											
35															1		1	1			1									

The next step was to determine the probability of retirement and resignation based on the empirical data available. Being limited by the information in the Register to the period 1959 - 1961, a very small sample was used to determine the various probabilities. For this reason the reliability of this model may be questioned, but for purposes of illustration and further study, it is felt to be adequate. The probabilities were determined by computing the proportion of officers within each longevity group that departed the service for reasons of resignation or retirement.

It should be noted that each of these longevity groups represents an infinite number of persons over a period of time and that the actual number within in a longevity group at any one time represents a sample of the population. Hence, when we consider what happened to a longevity group during any one period, as was done with this paper, we are considering a sample occurrence with its reliability being determined by the size of the sample.

Due to the fact that this sample was small, with inadequate data for several longevity groups, the computed probabilities were plotted and smooth curves drawn. (Figures II and III) The probability data necessary for the simulation was extracted from the graphs and is listed in Tables III and IV.

TABLE III

TABULATION OF RESIGNATION AND RETIREMENT PROBABILITIES
FOR LONGEVITY GROUPS 1 - 33
(Based on 1959-60 Data Extracted From CG-111)

Longevity Group	1959 Total	Resignations & Revocations	Retirements	Temp. Retirements	1960 Totals	Resignations & Revocations	Retirements	Temp. Retirements	1959-60 Totals	1959-60 Retirement	Retirement Probabilities	1959-60 Resignations	Resignation Probabilities
0	80				133				213				
1	87	1			82				169			1	.0059
2	60				87			1	147	1	.0068		
3	105	2		1	60				165	1	.0060	2	.0121
4	83	8			106	3		1	189	1	.0053	11	.0582
5	85	5			91	6			176			11	.0625
6	88	5			86	2			174			7	.0402
7	72	2			86				158			2	.0126
8	71				74	1			145			1	.0069
9	80				73			1	153	1	.0065		
10	100				86				186				
11	65	1			103		1		168	1	.0060	1	.0060
12	81	1			68	1			149			2	.0134
13	129			1	86				215	1	.0046		
14	116	1			128			1	244	1	.0041	1	.0041
15	85				116				201				
16	129				85				214				
17	129				130		2		259	2	.0077		
18	101			1	129				230	1	.0043		
19	50				100				150				
20	61		7		50		7	1	111	15	.1351		
21	40		2		54				94	2	.0212		
22	40		1		38				78	1	.0128		
23	40		3		39		1		79	4	.0506		
24	38		2	3	37		2		75	7	.0933		
25	32				33		1	1	65	2	.0307		
26	31		2		32		1		63	3	.0476		
27	31		1		29		1		60	2	.0333		
28	29		1		30		3		59	4	.0678		
29	19		3	3	28		5	2	37	13	.3513		
30	17		8	2	13		8	1	30	19	.6333		
31	8		3	1	7			1	15	5	.3000		
32	8		3		4		3		12	6	.5000		
33	3		1		5		2		8	3	.3750		

FIGURE II

PROBABILITY OF RESIGNATION FOR LONGEVITY GROUPS 0 - 20

(BASED ON DATA EXTRACTED FROM CG-111)

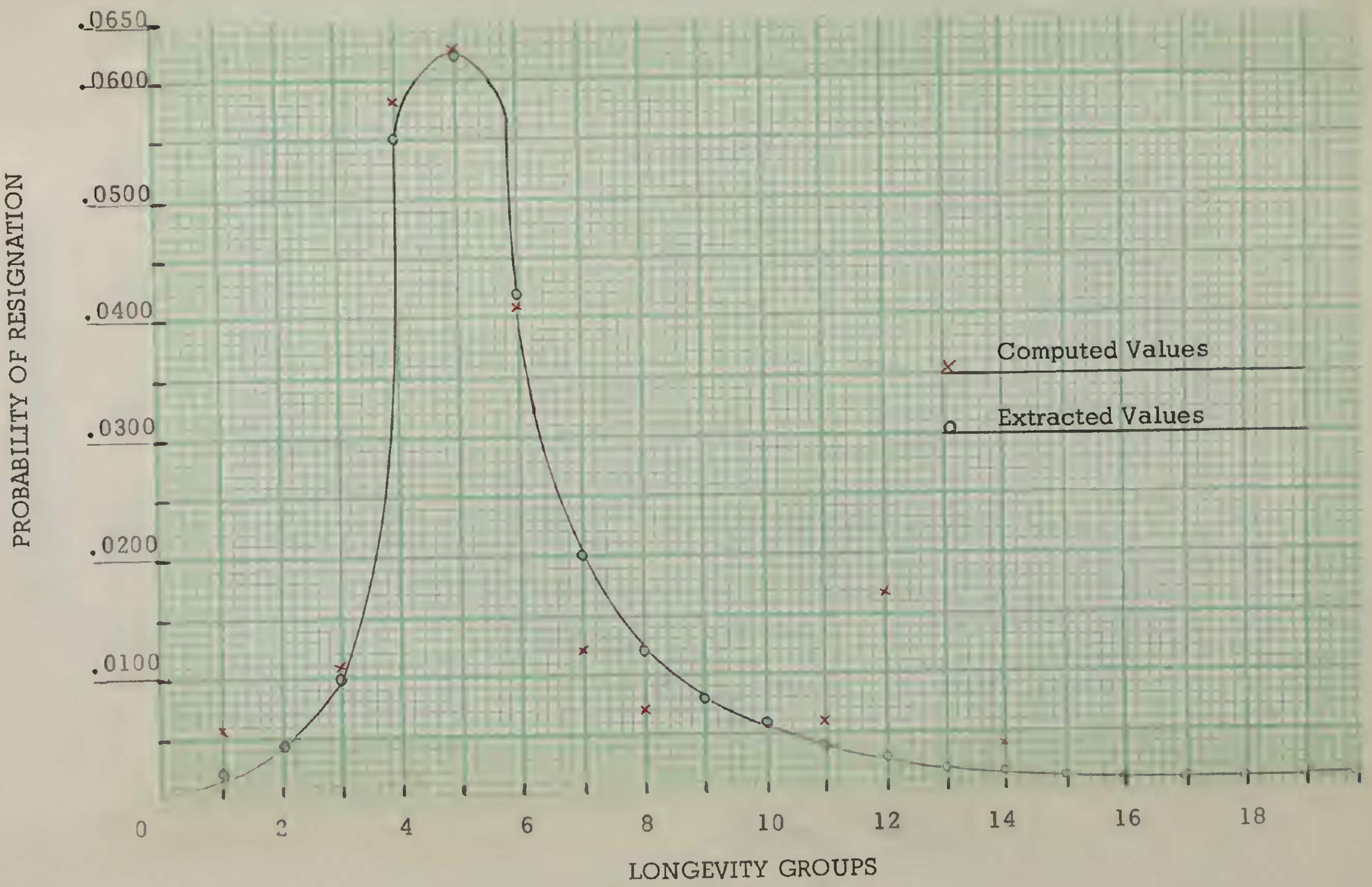


TABLE IV

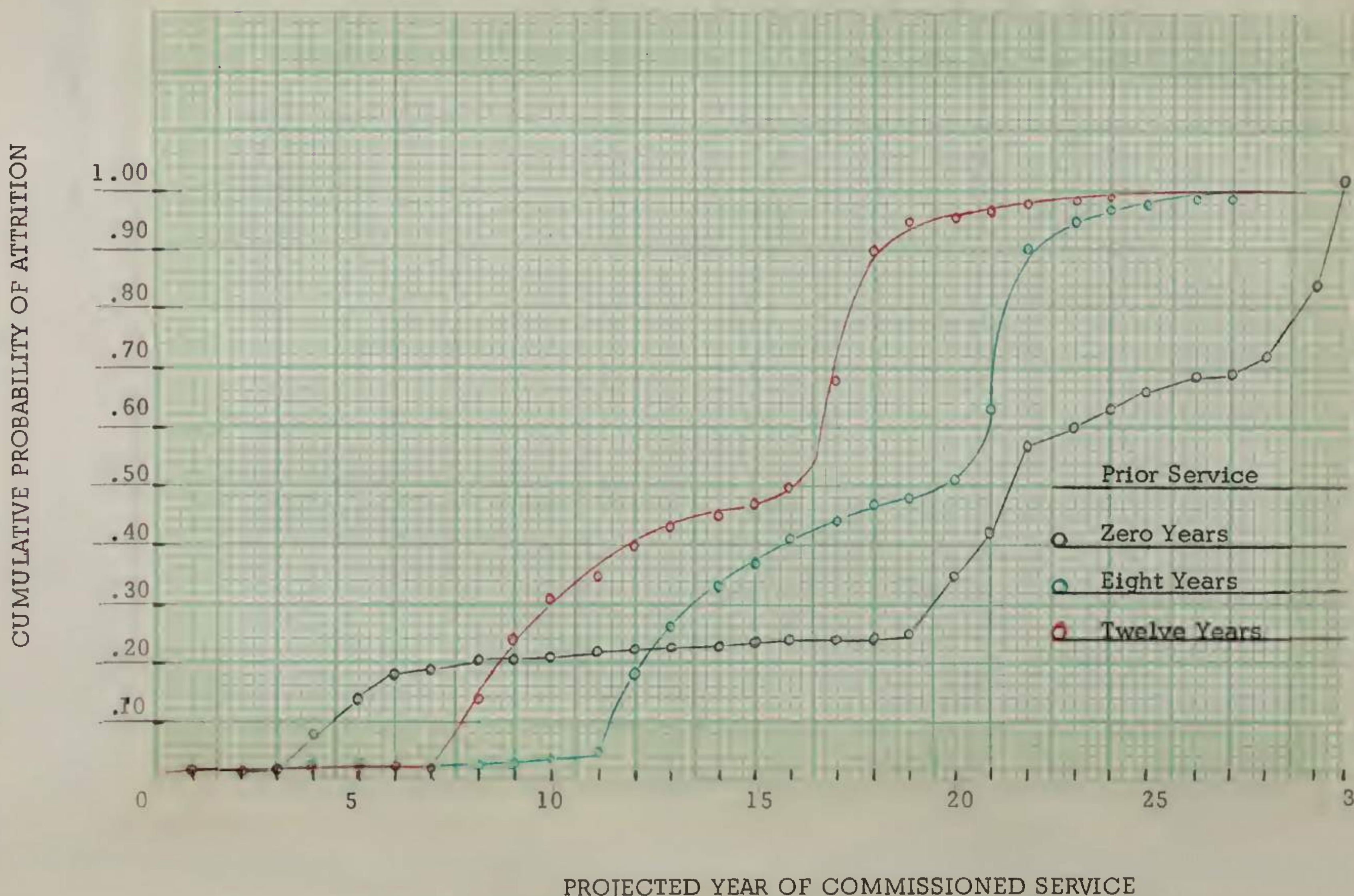
COMPARISON OF COMPUTED PROBABILITIES AND CHARTED PROBABILITIES
(CHARTED PROBABILITIES USED BECAUSE OF INADEQUATE DATA)

Longevity Group	Computed Resignation Probability	Charted Resignation Probability	Computed Retirement Probability	Charted Retirement Probability
1	.0059	.0020		.0020
2		.0040	.0063	.0020
3	.0121	.0100	.0060	.0020
4	.0582	.0540	.0053	.0020
5	.0625	.0620		.0020
6	.0402	.0420		.0020
7	.0126	.0200		.0020
8	.0069	.0120		.0020
9		.0080	.0065	.0020
10		.0050		.0020
11	.0060	.0040	.0060	.0020
12	.0134	.0030		.0020
13		.0020	.0046	.0020
14	.0041	.0020	.0041	.0020
15		.0010		.0020
16		.0010		.0020
17		.0005	.0077	.0020
18		.0005	.0043	.0020
19		.0005		.0020
20			.1351	.1300
21			.0212	.1100
22			.0128	.0900
23			.0506	.0700
24			.0933	.0600
25			.0307	.0500
26			.0476	.0400
27			.0333	.0300
28			.0678	.0600
29			.3513	.3500
30			.6366	.6700
31			.3000	.5500
32			.5000	.4300
33			.3750	.3700

TABLE V
CUMULATIVE PROBABILITY OF ATTRITION FOR
LONGEVITY GROUPS ZERO THROUGH FOURTEEN
LONGEVITY GROUPS

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14
	[illegible]	[illegible]	[illegible]	.0560	[illegible]	[illegible]	.0220	.0140	.0100	.0070	.0060	.0050	.0040	.0040	[illegible]
	[illegible]	[illegible]	.0640	.1165	.0991	.0631	.0357	.0234	.0167	.0130	.0110	.0090	.0080	.0070	[illegible]
	[illegible]	[illegible]	.1243	.1556	.1191	.0763	.0454	.0302	.0226	.0179	.0150	.0130	.0110	.0100	[illegible]
	[illegible]	.1323	.1630	.1744	.1316	.0856	.0521	.0360	.0265	.0218	.0190	.0160	.0140	.0125	[illegible]
	[illegible]	[illegible]	.1817	.1863	.1405	.0921	.0578	.0408	.0304	.0257	.0220	.0190	.0165	.0150	[illegible]
	[illegible]	[illegible]	.1935	.1948	.1467	.0977	.0626	.0447	.0343	.0286	.0250	.0215	.0190	.0175	.1417
	[illegible]	.2009	.2019	.2008	.1521	.1024	.0664	.0486	.0372	.0315	.0275	.0240	.0215	.1452	[illegible]
	[illegible]	.2092	.2078	.2059	.1566	.1061	.0702	.0515	.0401	.0340	.0300	.0265	.1487	.2403	[illegible]
	[illegible]	.2151	.2129	.2102	.1602	.1098	.0731	.0544	.0426	.0365	.0375	.1530	.2423	.3086	[illegible]
	.2184	.2206	.2172	.2137	.1638	.1127	.0760	.0569	.0451	.0390	.1626	.2461	.3104	.3569	[illegible]
	.2235	.2243	.2207	.2172	.1666	.1156	.0785	.0594	.0476	.1640	.2547	.3139	.3586	.3954	[illegible]
	.2278	.2280	.2242	.2200	.1694	.1180	.0810	.1619	.1714	.2559	.3217	.3619	.3970	.4256	.4445
[illegible]	.2313	.2317	.2270	.2228	.1718	.1204	.0835	.1838	.2625	.3228	.3691	.4001	.4271	.4485	[illegible]
[illegible]	.2348	.2344	.2298	.2252	.1742	.1228	.2026	.2845	.3288	.3702	.4069	.4301	.4500	.4650	.4943
15	.2375	.2371	.2321	.2276	.1766	.2368	.2903	.3488	.3757	.4079	.4365	.4529	.4665	.4971	[illegible]
16	.2402	.2395	.2344	.2300	.2836	.3207	.3541	.3929	.4131	.4375	.4580	.4693	.4985	.6731	[illegible]
17	.2425	.2419	[illegible]	[illegible]	.3624	.3818	.3993	.4293	.4424	.4600	.4742	.5011	.6740	.8921	[illegible]
[illegible]	.2448	.2443		[illegible]	.4197	.4250	.4353	.4578	.4647	.4762	.5057	.6757	.8924	.9514	[illegible]
	.2471	.3425			[illegible]	[illegible]	[illegible]	[illegible]	.4807	.5076	.6787	.8929	.9515	.9723	[illegible]
	.3449	.4148			[illegible]	[illegible]	[illegible]	[illegible]	.5118	.6799	.8939	.9518	.9723	.9825	[illegible]
	.4169	.4674			[illegible]	[illegible]	[illegible]	[illegible]	.6826	.8943	.9522	.9725	.9825	.9886	.9926
[illegible]	.4693	.5046					[illegible]	.6914	.8952	.9524	.9727	.9826	.9889	.9927	.9956
	.5064	.5343					[illegible]	[illegible]	.9528	[illegible]	.9828	.9837	.9927	.9957	
	.5360	.5575						[illegible]	.9730	[illegible]	.9888	.9928	.9953		
	.5592	.5752						[illegible]	[illegible]	[illegible]	.9928	.9958			
	.5768	.5879						[illegible]	[illegible]	.9928	.9953				
	.5894	.6126						[illegible]	[illegible]	[illegible]					
	.6140	.7481	[illegible]					[illegible]	[illegible]						
	.7491	.9148	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]						
	.9172	.9616	[illegible]			[illegible]	[illegible]	[illegible]							
	.9627	.9781	[illegible]			[illegible]	[illegible]								
	.9787	.9862	.9911		[illegible]										
	.9866	.9910	.9943	[illegible]	[illegible]										

FIGURE IV
CUMULATIVE PROBABILITY OF ATTRITION PATTERNS
FOR INDIVIDUALS
WITH ZERO, EIGHT, AND TWELVE YEARS PRIOR SERVICE



With the probabilities determined for the individual longevity groups, Figures II and III, it was now possible to combine this data and determine a cumulative probability of attrition for an entire system. To illustrate, for an individual with no prior service the probability for attrition by resignation and retirement during the first year is .002 and .002 respectfully, resulting in a .996 probability of the individual starting his second year. During the second year, there is a .004 chance of resignation and a .002 chance of retirement which must be applied to the .996, resulting in a .990 chance of the individual starting his third year. This procedure was carried out to compute the cumulative probabilities of attrition for individuals starting the system with no prior service, and for various amounts up to fourteen years prior service (Table V). As a matter of interest several of these cumulative probabilities were plotted on Figure IV to illustrate the relative positioning of similar trends which will be brought out by these simulations.

The simulation process. To exemplify the simplicity and versatility of simulation, several different types are illustrated utilizing the Monte Carlo method of analysis. The first type projects the officer component as it existed in 1959, through the year 1974 simulating each year group independently. The second simulation represents a thirty three year projection of one particular year group utilizing cumulative probabilities.

The officer component 1959 - 1974. For the first simulation, random numbers were assigned to the probability distributions illustrated in Table IV as required by the Monte Carlo method of analysis. The next step involved using the random numbers to represent the decisions of each officer in the organization concerning resignation and retirement, year by year, throughout the fifteen year period.

To illustrate the progression of a year group through the simulation, Figure V has been included. It should be apparent from this illustration that the total strength of the group may be tabulated at any time during the process. A similar process was conducted for each year group in the service in 1959, and included the additions of the 1960 and 1961 groups as they entered the service. A summary of this simulation is illustrated in Table VI. For reasons of curiosity, the cumulative totals from the simulation were distributed through the rank structure using the Bolte recommendations for rank distribution, and taking into consideration three variations of the allowable personnel strength: thirty one hundred, thirty three hundred, and the maximum of thirty five hundred. (Figures VI, VII, and VIII)

The initial reaction to this type of simulation might be that the same results could be obtained by applying average attrition rates to the different groups within the year groups with the overall results being the same. This may be so, but we are not considering a system that follows an exact order of sequence and for this reason

FIGURE V

SIMULATION OF YEAR GROUP 1944

1959 - 1974

PROJECTED YEAR

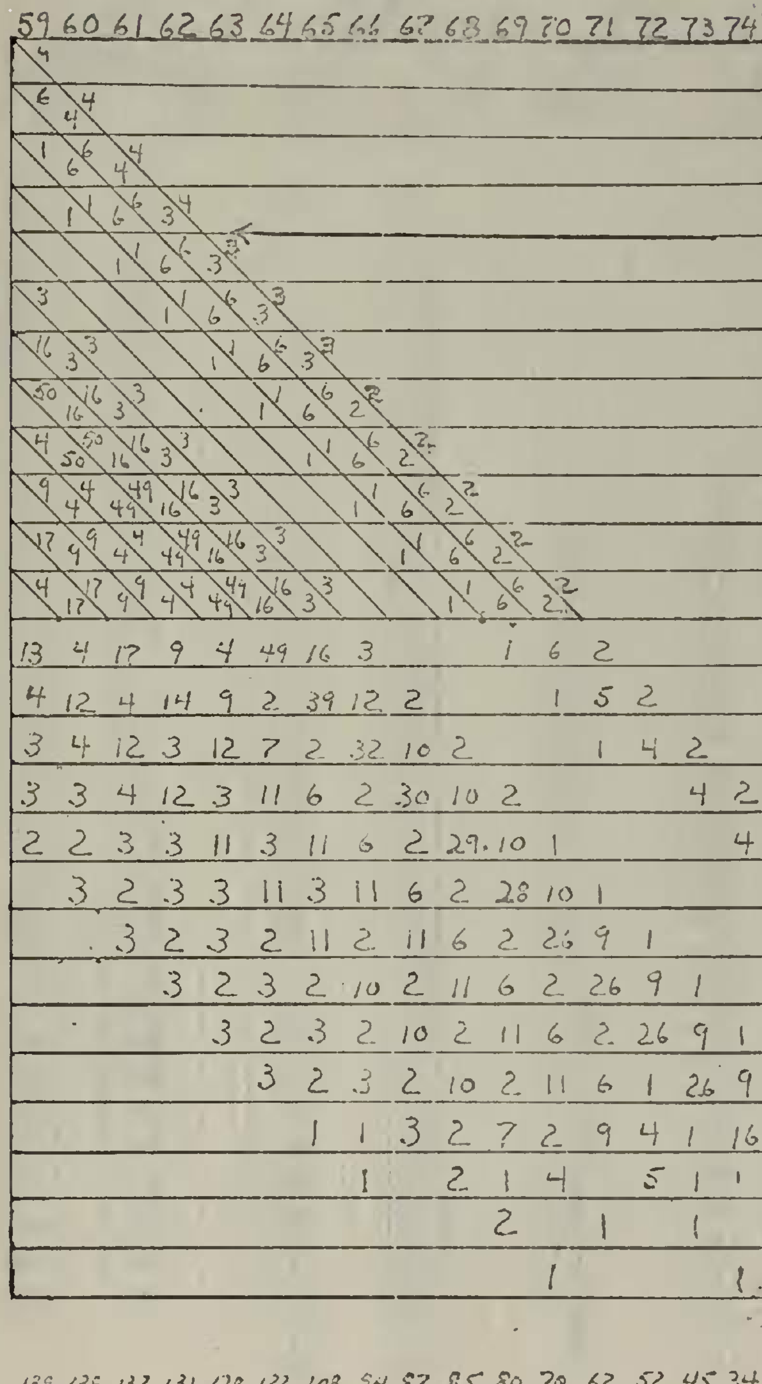
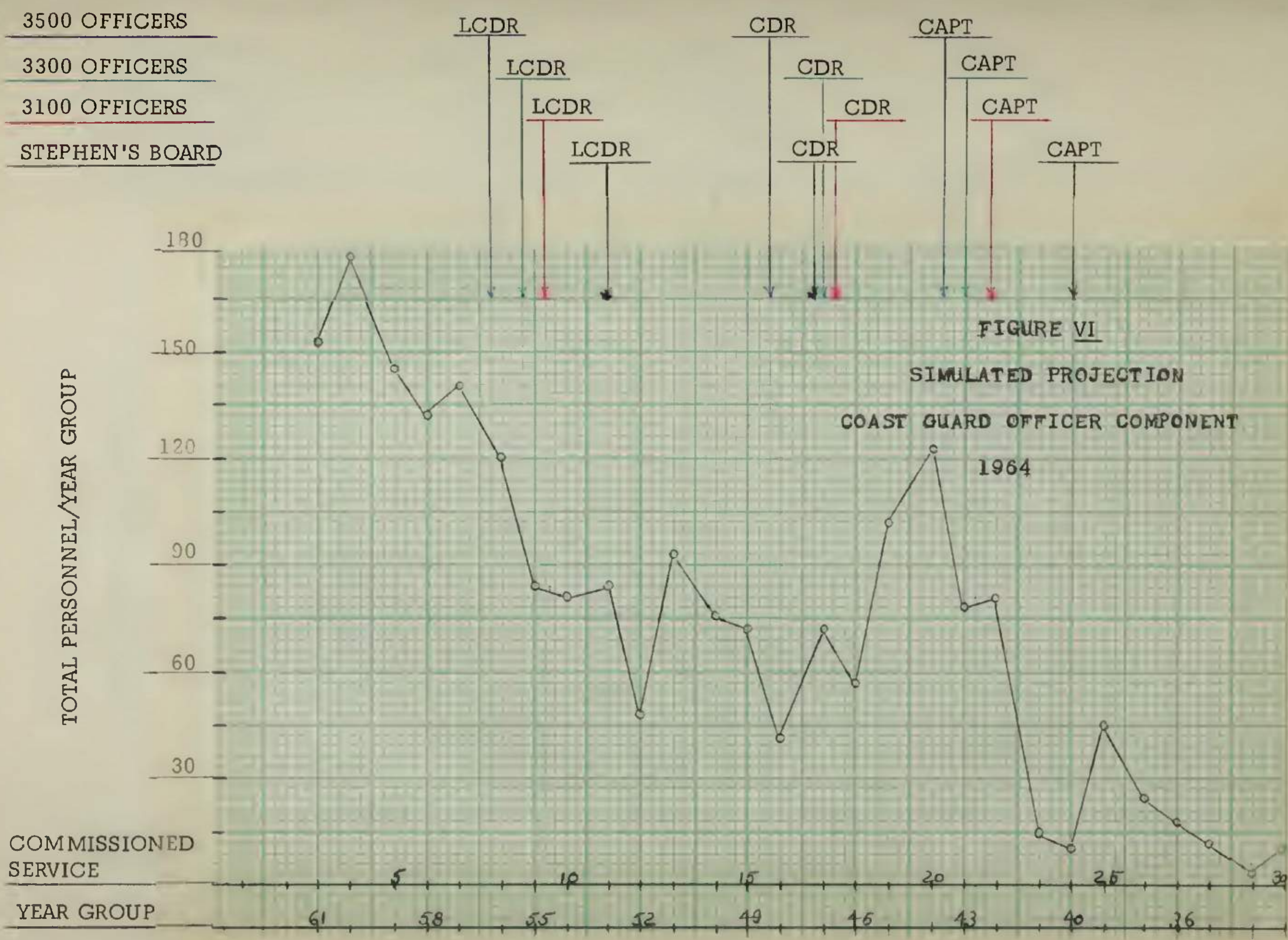
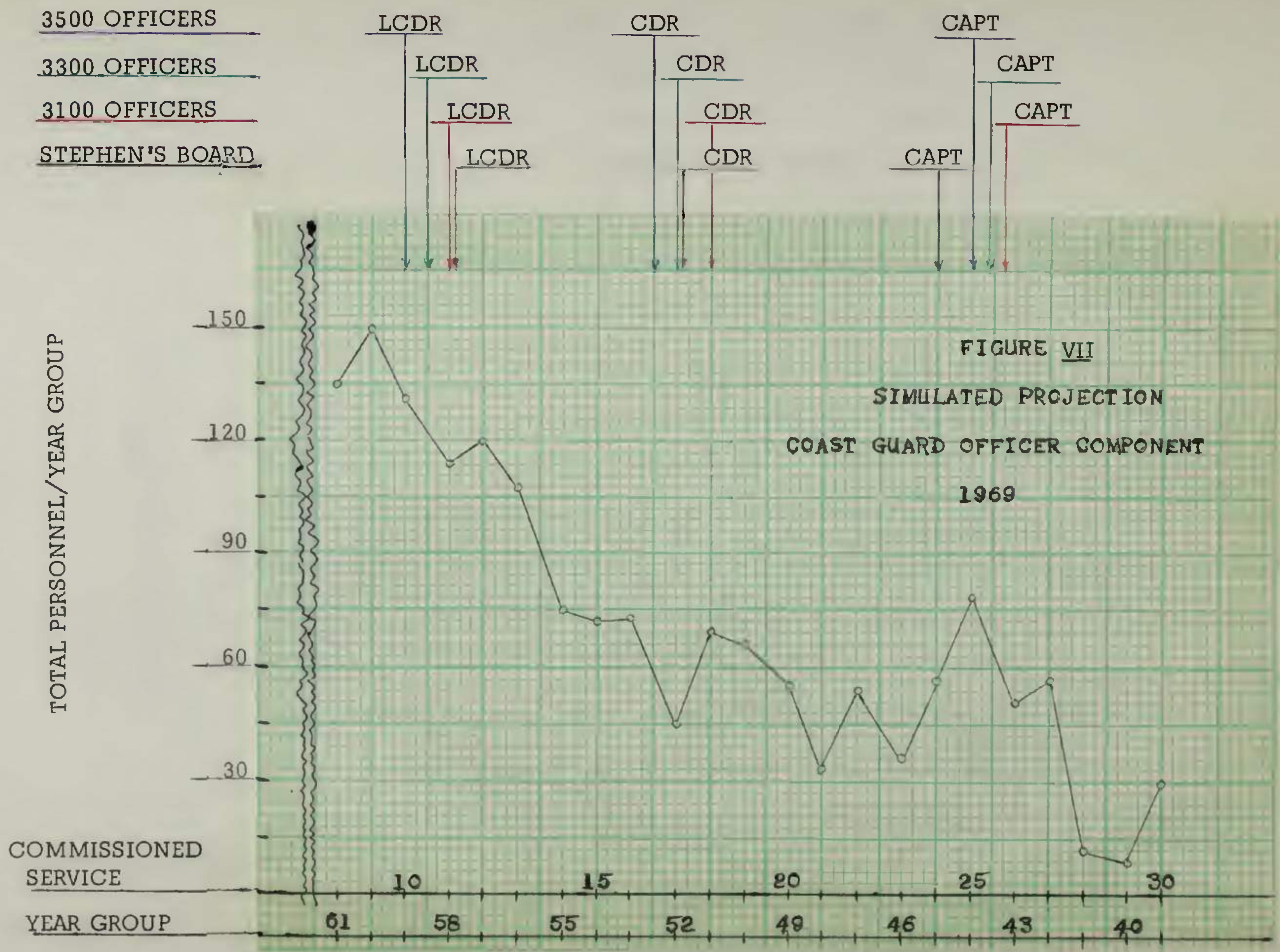


TABLE VI

SUMMARY OF DATA EXTRACTED FROM INDIVIDUAL YEAR GROUP SIMULATIONS

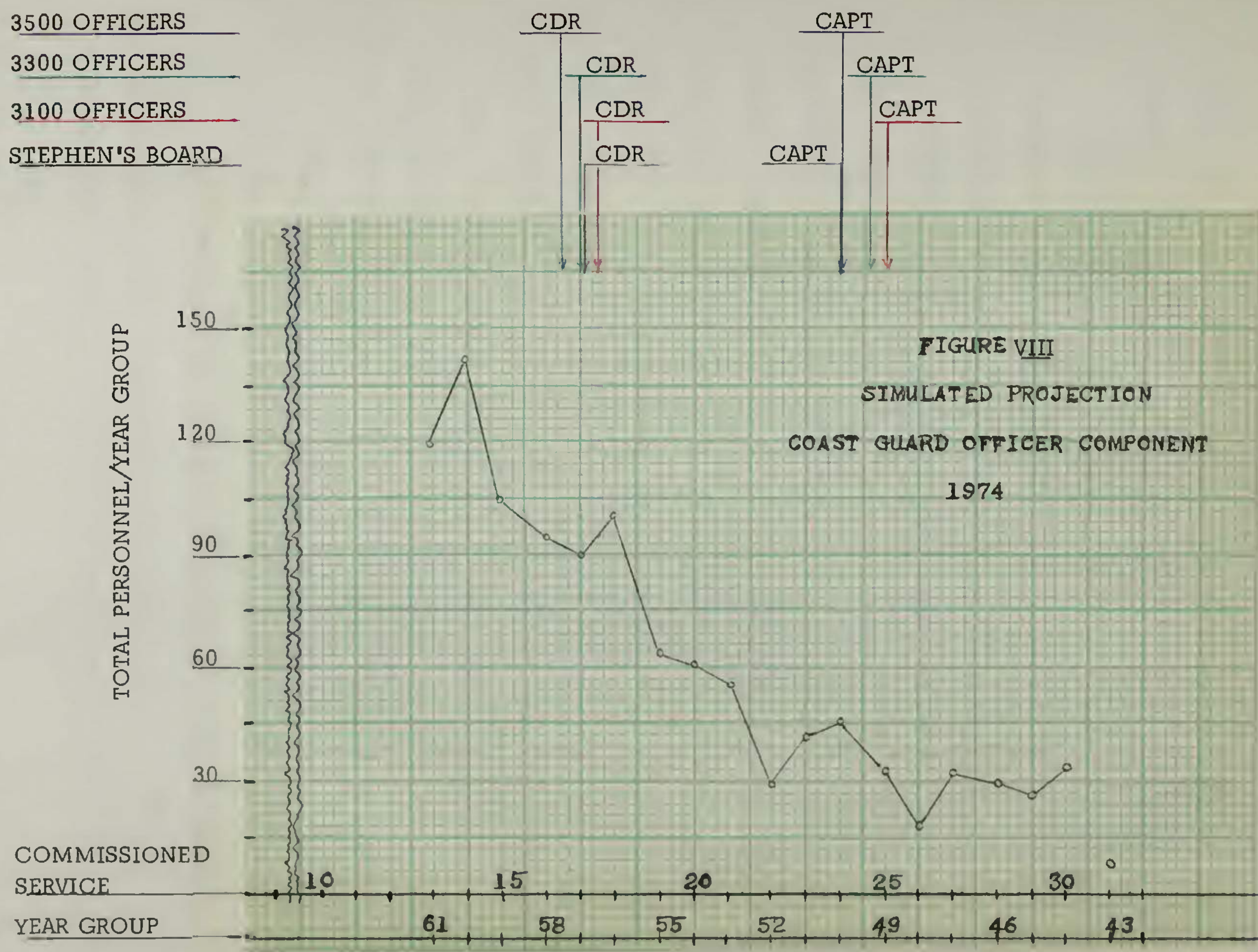
Year Group	Actual 1959 Data	1959 Cumulative	Simulation 1964 Totals	1964 Cumulative	Simulated 1969 Totals	1969 Cumulative	Simulated 1974 Totals	1974 Cumulative
27	4	4						
28	4	8	1	1				
29	3	11	0	1				
30	14	25	1	2				
31	23	48	1	3				
32	25	73	2	5				
33	21	94	7	12				
34	3	97	0	12				
35	21	118	12	24	1	1		
36	29	147	19	43	1	2		
38	38	185	24	67	2	4		
39	67	255	46	113	31	35	2	2
40	17	272	10	123	9	44	2	4
41	31	303	15	138	11	55	1	5
42	111	414	80	218	57	112	3	8
43	102	516	79	297	52	164	8	16
44	139	655	122	419	80	244	34	50
45	137	792	102	521	58	302	29	79
46	59	851	57	578	39	341	31	110
47	89	940	73	651	55	396	32	142
48	42	982	41	691	33	429	19	161
49	88	1070	74	765	54	483	33	194
50	75	1145	75	840	69	552	46	240
51	100	1245	94	934	71	623	42	282
52	49	1294	47	981	44	667	31	313
53	99	1393	83	1064	76	743	57	370
54	96	1489	83	1147	72	815	62	432
55	100	1589	84	1231	76	891	64	496
56	140	1729	120	1351	108	999	101	599
57	154	1883	141	1492	121	1120	90	687
58	147	2030	130	1622	113	1233	95	782
59	162	2192	151	1773	129	1362	105	887
60			182	1955	152	1514	139	1026
61			156	2111	131	1645	120	1146


3500 OFFICERS
3300 OFFICERS
3100 OFFICERS
STEPHEN'S BOARD
LCDR
LCDR
LCDR
LCDR
CDR
CDR
CDR
CDR
CAPT
CAPT
CAPT
CAPT
FIGURE VI
SIMULATED PROJECTION
COAST GUARD OFFICER COMPONENT
1964
TOTAL PERSONNEL/YEAR GROUP
180
150
120
90
60
30
COMMISSIONED SERVICE
5
10
15
20
25
30
YEAR GROUP
61
58
55
52
49
46
43
40
36



3500 OFFICERS
3300 OFFICERS
3100 OFFICERS
STEPHEN'S BOARD
LCDR
LCDR
LCDR
LCDR
CDR
CDR
CDR
CDR
CAPT
CAPT
CAPT
CAPT
TOTAL PERSONNEL/YEAR GROUP
150
120
90
60
30
COMMISSIONED SERVICE
YEAR GROUP
10
15
20
25
30
61
58
55
52
49
46
43
40
FIGURE VII
SIMULATED PROJECTION
COAST GUARD OFFICER COMPONENT
1969

FIGURE VIII
SIMULATED PROJECTION
COAST GUARD OFFICER COMPONENT
1974



3500 OFFICERS
3300 OFFICERS
3100 OFFICERS
STEPHEN'S BOARD
CDR
CDR
CDR
CDR
CAPT
CAPT
CAPT
CAPT
TOTAL PERSONNEL/YEAR GROUP
150
120
90
60
30
COMMISSIONED SERVICE
YEAR GROUP
10
15
20
25
30
61
58
55
52
49
46
43
FIGURE VIII
SIMULATED PROJECTION
COAST GUARD OFFICER COMPONENT
1974

we should be interested in the range of possible outcomes that result from this process assumed to be random.

The results illustrated in Figure V and Table VI represent one of many possible outcomes that should be considered when planning the personnel structure.

Referring to Figures V, VI, and VII, I would like to explain in more detail the illustrations. Having completed the fifteen year simulation, it was possible to extract the data for any particular year from the model as illustrated in Figure V. Hence the totals for 1964, 1969, and 1974 were tabulated and cumulative totals computed (Table VI). With this data an effort was made to illustrate an advantage of simulation by distributing the outcome through a rank structure and comparing it with the career pattern being strived for by current policy. The method of distribution utilized was to compute the number of captains, commanders, etc., that would be authorized using the Bolte Commission recommendations for distribution of rank and various personnel allowances. The personnel were then distributed through the rank structure by year group. Indications have been made at the top of the figures to point out the cut off for various ranks using the three variations of personnel allowance. A further indication was made for the goals set by the Stephen's Board for a career pattern.

> A basic element of the career pattern established by the boards envisions the promotion of officers to LTJG at the completion of eighteen months service, to LT at four years service, to LCDR at eleven years service, to CDR at seventeen years service and to CAPT not later than twenty four years service. These figures of course represent a goal to be achieved when possible.[20]

The point that I am trying to make in comparing the career goals with the projection of the simulation, is not the similarity of the two, but instead the advantages of being able to evaluate more alternatives with a better prospective of the complete system prior to making a decision.

Year group 1961 attrition projection. The second type of simulation described, represents the projection of one particular year group over a thirty three year pattern. It is this type of simulation that should be helpful in determining the required input to the officer system necessary to maintain the continuous flow strived for with forced attrition programs.

Year group sixty one was selected for projection by simulation of an attrition pattern. The simulation was conducted as follows:

1. Each of the separate longevity groups within year group sixty one were simulated independently using the cumulative probabilities determined for the respective groups (Table V).

---

[20]United States Coast Guard, Weekly Report of Activities, (Washington: Treasury Department, 23 March, 1963).

2. Referring to Table VII, the first one hundred and eighteen numbers represented the group with zero years prior service, the next number the individual with one year prior service etc.,until all fifteen longevity groups had been simulated.

3. The attrition patterns were constructed by taking the numbers extracted from the random number table and comparing it to the cumulative probability for the longevity group concerned and the time of attrition will be indicated by the left hand column of Table V.

This procedure was carried out for each longevity group in year group sixty one and the tabulated results are illustrated in Table VIII and Figure IX.

The results of this particular simulation, once again do not necessarily mean that this is the definite pattern for year group sixty one because it was conducted with sparse data and was primarily for illustrative purposes. However, I feel that simulations of this type would be beneficial in determining Academy class sizes, future officer candidate policies, and in solving numerous other officer and enlisted personnel problems.

TABLE VII

EXCERPT FROM RANDOM NUMBER TABLE

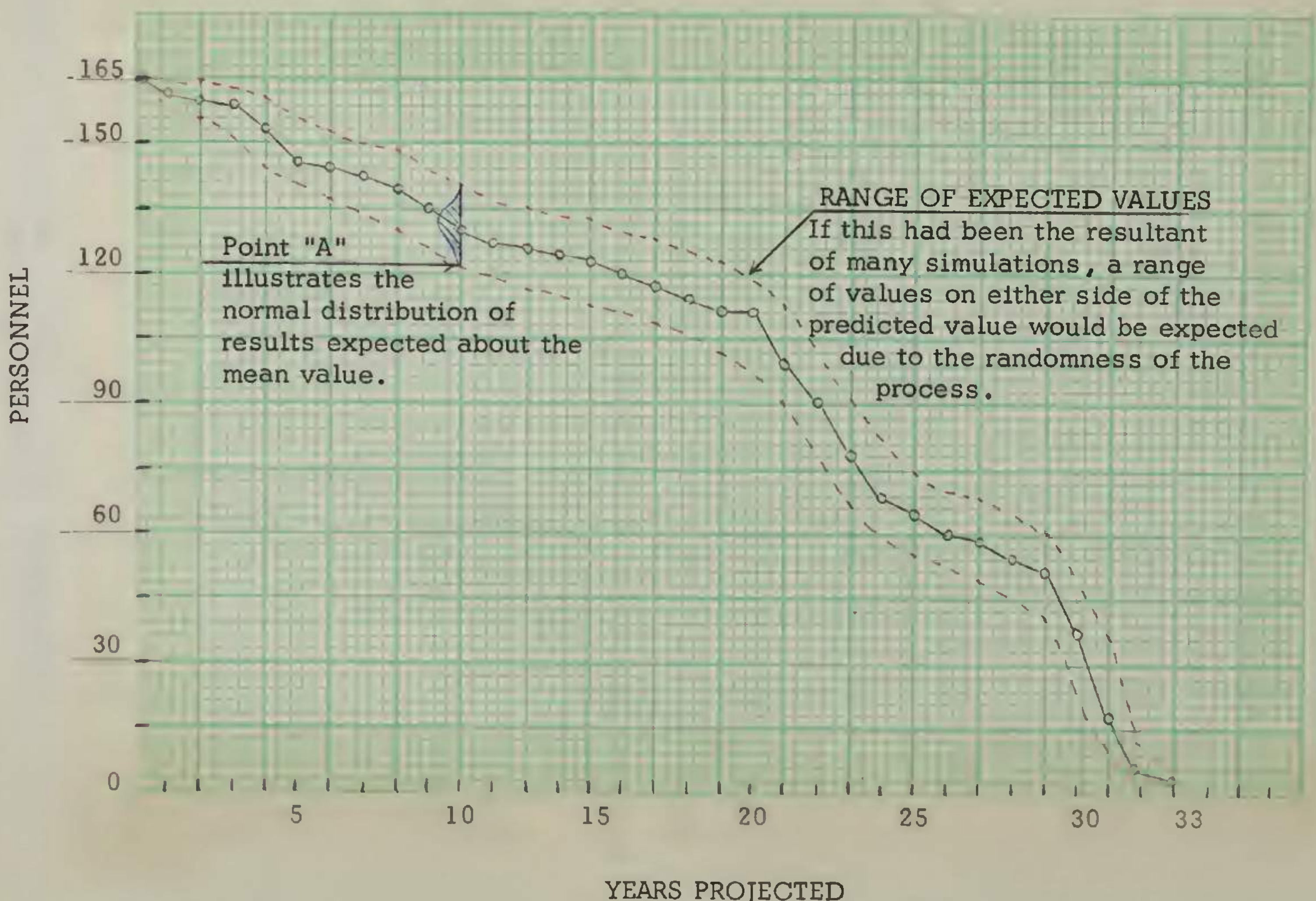
59844	58723	00049	27149	57407	36808	07016	17174	43461	49223	88994
12262	13303	91202	54054	05110	53401	86902	70088	74501	30083	98813
65215	18030	55843	35296	26268	27101	06971	49455	38249	87252	97477
72447	10493	18477	39502	10723	95205	74636	58282	43756	75555	65080
20203	17288	68676	31283	17594	40044	05289	19754	97974	12055	86892
42979	67093	75476	25312	00227	42334	96117	63572	81234	70337	76197
35173	16173	77500	32921	36612	99822	98524	17900	34985	71520	40720
07330	76615	20972	84490	38899	01743	45385	44457	67442	73146	60977
48596	90718	92884	31200	92818	12775	55860	86902	88241	55608	78793
77495	70324	50323	44441	37427	14990	15222	94033	11416	19086	88814
40259	57595	33361	55230	55307	49130	75436	27240	41914	77587	56275
58246	21582	46177	71390	61062	21690	37129	58241	71122	59036	15551
61101	15033	31768	67129	86532	64024	69389	28702	51633	21678	69562
04755	51221	44593	46622	51428	58416	91270	55106	70538	59222	25845
18624	05095	70524	95836	24943	25359	78956	98953	88610	76011	88314
47405	57460	20103	49620	45431	08755	98228	34796	88746	56820	26942
43258	95534	37336	44598	21812	47574	37461	71134	51379	02560	59237
78054	33053	76625	40139	85260	15936	19764	06393	52717	26632	03645
98709	48697	99745	57371	27845	89562	97060	34924	74216	40330	62153
[illegible]	[illegible]	[illegible]	80130	99113	60898	15979	21744	31802	00506	70014
59971	68414	[illegible]	98328	[illegible]	03650	28584	46795	61673	18108	53097
08945	73498	[illegible]	90670	70068	44249	36142	58168	49415	81671	40515
56387	98581	50540	43657	79599	79340	56881	39843	73894	04555	17874
95291	50990	88317	18046	23668	10620	87401	91948	77129	11243	71657
48269	12957	89398	73619	77078	38993	52967	80016	64932	44532	18121
30129	45255	61883	86928	40119	10822	81133	28040	49345	19326	81373
60384	92751	24437	92878	41118	45281	95549	34677	50057	11832	95817
90697	81527	45677	01301	33776	90315	24528	24802	44516	96779	92902
69348	59490	41924	15472	63692	04948	54391	85001	81344	19270	75069
31541	95745	00621	81689	34455	31882	85116	57733	55992	50017	69765
07365	83787	80609	25283	43880	74610	57662	59244	24173	03354	79635
33863	12770	71142	62815	68375	38877	56590	32717	83166	75115	57113
41459	65791	07517	31296	21168	07574	03736	96848	41439	32621	21084
70245	13564	[illegible]	07083	91845	10533	53807	91347	09534	14579	22803
[illegible]	[illegible]	[illegible]	46900	[illegible]	[illegible]	[illegible]	53535	71292	63616	23231
58710	07935	[illegible]	88032	98758	[illegible]	37332	16278	22901	[illegible]	71881
95137	62174	33595	37878	94551	58611	42854	62566	[illegible]	[illegible]	51051
98023	35566	75951	38293	59501	26781	35887	91719	09673	42461	06902
77543	97236	96376	43223	94208	13244	21477	64503	07954	96465	[illegible]
49743	03178	22000	50815	29131	30757	27226	27128	35960	56002	[illegible]
[illegible]	[illegible]	90120	[illegible]	[illegible]	98409	12294	[illegible]	[illegible]	[illegible]	[illegible]
43027	24338	32308	95011	44996	58065	14245	38794	96652	[illegible]	[illegible]
[illegible]	99431	75074	[illegible]	[illegible]	59090	18052	66650	[illegible]	[illegible]	[illegible]
[illegible]	53974	95606	[illegible]	[illegible]	[illegible]	[illegible]	37026	[illegible]	[illegible]	43707
63332	75695	13101	[illegible]	[illegible]	[illegible]	15685	23670	11916	86257	11694
[illegible]	71818	49139	99027	08534	[illegible]	27332	[illegible]	35922	23943	91989
[illegible]	03952	98657	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17337	69739	60577
08557	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	93710	[illegible]	[illegible]	[illegible]	94755
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	64610	[illegible]	[illegible]	60063	63518
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85573	[illegible]	[illegible]	[illegible]	[illegible]

TABLE VIII
TABULATION OF SIMULATION DATA
(ATTRITION PATTERN OF YEAR GROUP '61)

LONGEVITY GROUPS

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	
1	1						1									2	2
2			1													1	3
3				1												1	4
4	6				1											7	11
5	7															7	18
6	1															1	19
7	4															4	23
8	1												1			2	25
9	2													1		3	28
10	2												1	2		5	33
11										1			2			3	36
12													2			2	38
13														1		1	39
14							1	1								2	41
15							1								11	3	44
16						1									1	2	46
17								1					1	1		3	49
18					1						1	1				3	52
19																	52
20	11					1										12	64
21	9				1											10	74
22	9							1	1							11	85
23	4							2	1		1					8	93
24	1					1	3									5	98
25	1					2		1	1							5	103
26	1															1	104
27	3															3	107
28	5															5	112
29	14															14	126
30	20															20	146
31	10															10	156
32	2															2	158
33	4	1														5	163
TOTALS	118	1	1	1	2	6	4	7	4	1	2	1	7	5	3	163	

FIGURE IX
ATTRITION PATTERN OF YEAR GROUP 1961
PROJECTED OVER A THIRTY THREE YEAR PERIOD
(BASED ON A SINGLE SIMULATION



CHAPTER V

SUMMARY AND CONCLUSIONS

Summary. The problem presented at the outset of this study was compared with the basic economic problem of how much of what should be produced and to whom should it be distributed. The uncertainty of how many officers the Coast Guard should commission, how they should be trained, and to what specialty they should be channeled has not been removed by this study. However, a new tool has been introduced which should reduce the uncertainty concerning these problems. The process of simulation should not be construed to be a panacea for the problem of planning for uncertainty. It does however, offer a tool for improving the utilization of empirical data that has been or should have been collected throughout the history of the organization. It should allow us to look at large complex systems and observe reactions of certain segments or of the entire system to various stimuli, which until very recently had not been general practice.

Simulation strives for the optimum alternative instead of accepting the satisfactory alternative which has been the practice of the past. Simon and March distinguish between these two alternatives by using the analogy of looking for any needle in the hay stack and looking for the sharpest needle in the hay stack.[21]

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[21]James G. March and Herbert A. Simon, Organizations (New York: John Wiley and Sons Inc., 1958), p. 141.

The advantages of the simulation process over the trial and error method of analysis are (1) the ability to accelerate the time for testing various alternatives; (2) the acquiring of less financial risk and investment for new programs; (3) the ability to look at the whole system and its reactions to various alternatives instead of one small segment; and (4) the ability to pursue many more alternatives in search of the optimum solution.

The Monte Carlo method of analysis has been utilized for several reasons. First, it is a fairly simple process which does not require much formal training to be understood or applied. Second, it lends itself very well to complex problems with mathematical solutions well beyond the realm of simple equations. Finally, the lack of necessity for machine computations and manipulations makes it available to all levels of Coast Guard administrators.

<u>Recommendations</u>. In concluding this paper it is recommended that refinements be made to this model by further study in order that it might serve some practical use to Coast Guard administrators. It is also recommended that the Monte Carlo method of analysis be considered by other than personnel administrators as a potential tool for removing uncertainty and searching out optimum alternatives. As pointed out by John Martinez in a research paper completed last year:

> The Monte Carlo technique of using a probability conditioned random sampling to construct a simulated version of the District's operations has been chosen, because this technique is readily adaptable to such a problem. Even more important, however, is the ability to manipulate the model so constructed to consider the effects of real or proposed changes. This adaptation to change without having to construct a new model, alone, recommends the Monte Carlo method for consideration.[22]

Conclusions. In conclusion it is felt that a definite need exists in the Coast Guard for an administrative tool, such as simulation. The adoption of simulation and this method of analysis would not only assist planners to overcome some of the uncertainty with which they are constantly faced, but would also introduce to the service a process in its development stage which industry will be making extensive use of in the near future. This point was made by Bowman and Fetter in explaining some of the uses of the Monte Carlo method:

> The Monte Carlo method has not been used extensively in solving some of the economic problems of production management as yet. The chances are that its use will increase for at least three reasons, as follows:
>
> 1. Though the method is relatively unknown to most manufacturers, more and more of them are being exposed to these ideas.
> 2. Uncertainty, which has always been a part of production problems, is now being more explicitly considered than before. Formal probability treatment is being given to more and more problems. Problems that will lend themselves to

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[22]John G. Martinez, "Simulation Of An Aids To Navigation Maintenance System" (unpublished research paper, U. S. Naval Postgraduate School, Monterey, California, 1961), p. 74.

formal mathematical treatment are being solved first. Problems that are too complex for formal treatment by most groups will remain to be solved by Monte Carlo.

3. Computers are becoming more a part of industrial management. The many trials and calculations necessary for Monte Carlo can be made more economically using these computers.[23]

The continued use of simulation by Coast Guard administrators should eventually provide the Commandant with the jurstification needed to convince Congress that program and budget adjustments are needed at a particular time in order to bring about a desired result in the future. To date it appears quite difficult to convince Treasury Department officials and Congress that policy changes and program alterations are necessary to avoid or create certain future conditions. It is hoped that with simulation the expected needs or conditions could be illustrated and the effect shown of various alternatives. In this way, justification of the optimum alternative should be easier, removing some of the uncertainties from our plans, and instilling more confidence in Congress for our programs.

[23]Edward H. Bowman and Robert B. Fetter, Analysis For Production Management (Homewood, Illinois: Richard D. Irwin, Inc., 1961), p. 358.

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